SAFETY IN PNEUMATIC DRILLING AND RELATED BLASTING OPERATIONS

OPENCUT MINE, MORENCI BRANCH, PHELPS DODGE CORP., MORENCI, ARIZ.

BY E. R. RODRIGUEZ AND A. D. LOOK

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Opencut Mine, Morenci Branch, Phelps Dodge Corp.,
Morenci, Ariz.

by

E. R. Rodriguez 1/ and A. D. Look 2/

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SUMMARY

Improved practice resulting from recent changes in the method of supplying compressed air and in pneumatic drilling equipment used in secondary drilling and in development work at the Morenci mine of the Phelps Dodge Corp., has resulted in improved safety conditions, as well as in a reduced cost per foot of drilling. A large stationary compressor installed outside the mining area and the compressed-air pipelines in the mine were replaced by portable compressor units. A self-propelled, self-contained drilling unit was obtained for drilling large footages where short moves were involved. Large wagon-drill units were replaced by faster and lighter drill machines and conventional bits by carbide insert bits.

The safe practices employed in air drilling and in the related blasting and scaling operations have contributed to an excellent safety record at this mine. The complete sets of instructions listed in the company codes of safe practice aid materially in training employees.

INTRODUCTION

Safety is considered of prime importance at the Phelps Dodge Corp. mining operations at Morenci, Ariz. The attention given to safety at the opencut mining operations of the company has resulted in accident-frequency rates[3/] ranging from 5.9 to 15.8 and of accident-severity rates[4/] ranging from 0.23 to 1.46 during the 5 years from 1948 to 1952.

Recent changes in pneumatic drilling equipment and in the method of supplying compressed air used in secondary drilling and in development work at the Morenci opencut mine have increased the safety and efficiency in these operations. These changes and the resulting improvements in safety are enumerated in this paper, and safe practices in the related blasting and scaling operations are recorded. The most pertinent of the detailed instructions provided by the company to guide its employees in codes of safe practice also are presented.

ACKNOWLEDGMENTS

The authors express their appreciation for the courtesies shown them by the mine officials and employees of the Phelps Dodge Corp. and for their helpful suggestions and information, which made possible preparation of this publication. Special acknowledgment is made for information supplied by L. Ormsby, mine superintendent; Paul C. Simmons, safety supervisor; and the various supervisors of the Air-Drilling Department.

All photographs were provided through the courtesy of the Phelps Dodge Corp.

3/ The total number of lost-time accidents per million man-hours of exposure.
4/ The days lost per thousand man-hours worked.

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GENERAL INFORMATION

The Morenci mine, in the Clifton-Morenci mining district in southeastern Arizona, is one of the largest opencut copper mines in the Nation. The bulk of the ore at this mine occurs in a low-grade, disseminated-porphyry deposit, with chalcocite as the principal copper mineral.

Mining benches are carried 50 feet in height. Electrically driven churn drills using 12-inch bits and a rotary drill with a bit of 7-3/8-inch diameter are used in primary drilling, and pneumatic drills are used on development work and in secondary drilling. The broken ore and waste are loaded with electric shovels with dippers of 5-, 6-, and 7-cubic yard capacity, and haulage is by both railroad trains and trucks. Trucks are used in development work and where it is not feasible to use trains.

As of June 1953 mining was at the rate of approximately 140,000 tons daily of waste and ore from a pit, which covered an area of approximately 1 mile square. The elevations of the topmost and the lowest mining benches were 5,550 feet and 4,450 feet above sea level. About 50 miles of standard-gage railroad track was involved in the haulage system, and all parts of the pit were made accessible by some 80 miles of roads.

PNEUMATIC DRILLING PRACTICE AND RELATED BLASTING OPERATIONS

As almost 100 percent of the drilling for primary blasting on the shovel benches of this mine is done with churn drills and a rotary drill, the use of pneumatic drills is limited to drilling in development work where it is not economical or feasible to use churn or rotary drills and for secondary drilling. In development work blast holes are drilled with air-operated drills in constructing roads and in establishing new benches. Secondary drilling is required in breaking boulders, removing an excessively protruding toe of banks, and leveling hard, uneven bottom to maintain proper grade.

Past Practice

With former practice, air for operating pneumatic drills was supplied from a compressor outside the mining area. Water for drilling was obtained from pipelines, which also supplied water for churn drilling and for use in dust control. Air and water pipelines were laid at the crest of the banks and maintained throughout the mine.

Pneumatic drilling was done with 4-inch machines mounted on heavy-weight, wagon-drill carriages using 1-1/4-inch round steel and detachable bits. Eight changes of steel were required for a 32-foot hole. Because of the heavy drilling equipment and the large amount of steel that had to be handled it was necessary to have a three-man crew for each machine. To reduce the required amount of drilling holes were sprung where possible.

Because of the shortage of materials for pipelines and because of inadequate air pressure in the longer airlines as the mine expanded, it became necessary to substitute another means of supplying compressed air for drilling.

Present Practice

After experimenting with small, portable compressors, which were mounted on pneumatic-tired 4-wheel carriages and moved as needed by towing with a large truck

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or a bulldozer, 4 truck-mounted compressor units and 1 self-propelled, self-contained drilling unit were adopted for use in supplying compressed air. Faster and lighter drill machines and detachable carbide insert bits were substituted for the larger drill machines and conventional bits that had formerly been used.

Organization

The Air-Drilling Department of this mine, along with the Primary-Drilling Department, is under the general supervision of the drilling and blasting foreman. Direct supervision in the Air-Drilling Department is provided by 1 general air-drill foreman, 2 drill foremen, and 2 subpowder foremen.

The usual working crew consists of 14 men on each of the 2 shifts, day and evening, as follows:

1 Truck driver.
1 Truck driver's helper.
4 Machine drillmen.
3 Machine drillmen's helpers.
2 Secondary powdermen.
3 Secondary powdermen's helpers.

These crews do all drilling done with pneumatic drills, load and blast the rounds and boulders that are thus drilled, and scale the banks of the pit where toe holes are to be drilled. The truck driver and helper service equipment in the field and move the larger truck-mounted compressed air units, the self-propelled drilling unit, and the wagon drills as the need arises. The driver also transports the crew.

Drilling

Boulders and high bottoms are drilled with jackhammers using two truck-mounted compressor units (fig. 1). The trucks are 1-1/2-ton capacity and powered by gasoline engines. Each of these truck units is equipped with a diesel-engine-driven rotary compressor of 210 c.f.m. capacity, 2 pressure water tanks, each with capacity to supply water for 1 drill for the entire shift, 2 air-motor-driven reels, each with 100 feet of 3/4-inch air hose, and 2 air-motor-driven reels, each with 100 feet of 1/2-inch water hose. These truck-compressor units are self contained, in that all equipment needed for drilling is carried on each truck. Racks are provided for the two 55-pound jackhammers and for drill steel. A trailer hitch is provided to tow a wagon drill whenever one is to be used.

Enough air is supplied by each of these compressors to operate 2 jackhammers or 1 lightweight wagon drill. On occasions, the toe of banks is drilled with a wagon drill with compressed air supplied by one of these units; however, the wagon drills with these compressors are not used for holes deeper than 16 feet, if possible, as drilling of long holes is slow, due to the limited air supply. In drilling with jackhammers the crew normally consists of 2 drillers and occasionally of 2 drillers with 1 helper for both drillers. Holes are drilled to a maximum depth of 20 feet with 1-inch round steel and carbide-insert bits. In drilling boulders holes are drilled approximately to the center of each boulder.

These truck-compressor units, relatively small and highly mobile, are driven by the drillers and serve in transporting the drill crew. At the end of the shift the units are driven to the mine yard, where the equipment is serviced and drilling supplies are replenished.

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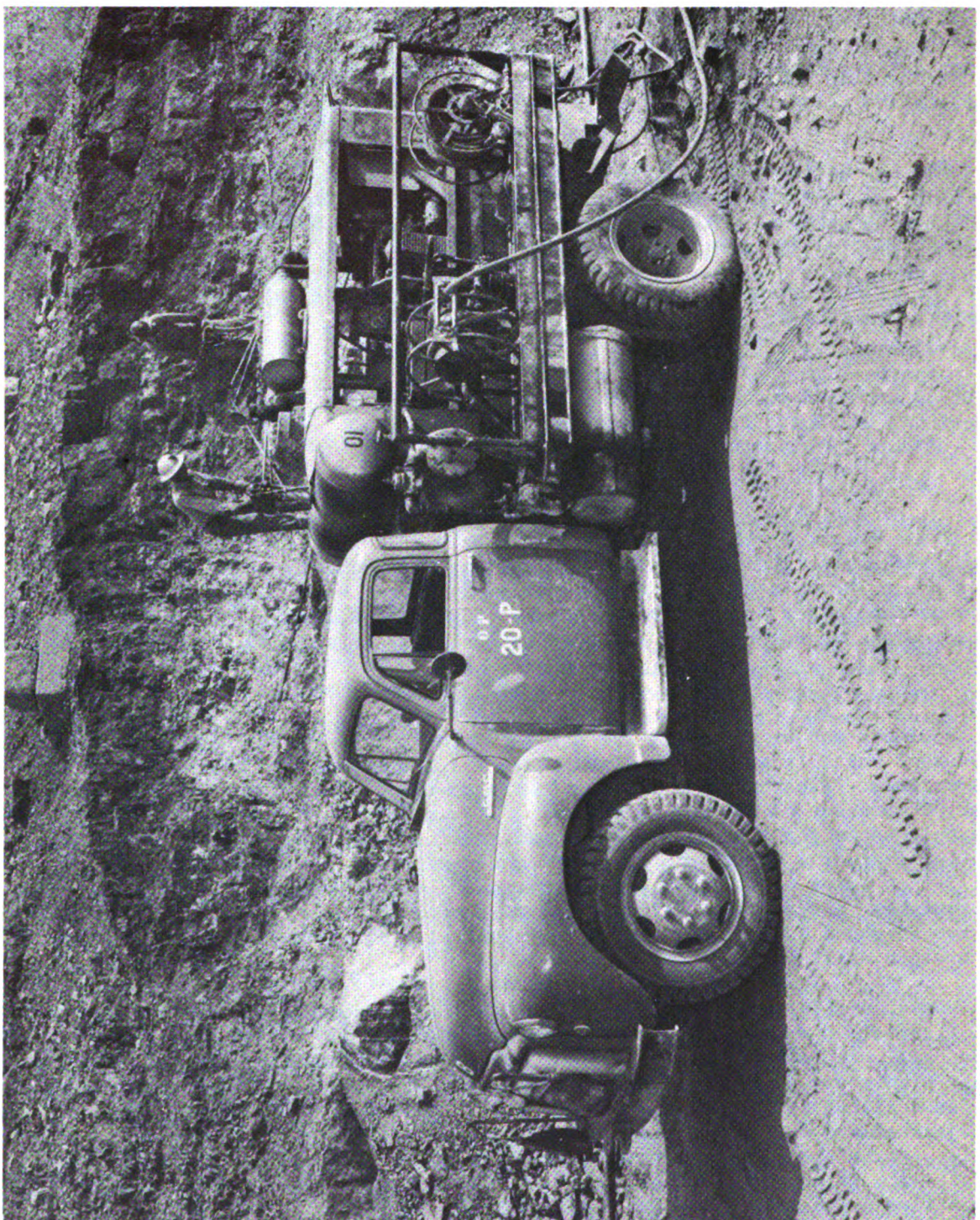

Figure 1. - Small mobile compressor unit. (All photographs courtesy Phelps Dodge Corp.)

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The 2 remaining truck-mounted compressor units (fig. 2) are used principally in drilling the toe of banks with lightweight 3-1/2-inch drills mounted on rubber-tired, 3-wheel, wagon-drill carriages. The trucks are 5-ton capacity, gasoline-engine-driven, and each is equipped with a diesel-engine-driven, piston-type compressor of 315 c.f.m. capacity. Two pressure water tanks, 2 reels with 1-inch air hose, 2 reels with 1/2-inch water hose, racks for 2 jackhammers and for drill steel, and a trailer hitch are also provided on each truck. Each of these compressors provides a supply of air adequate to operate one of the lightweight wagon drills or two 55-pound jackhammers, which are occasionally used with these units for drilling boulders and high bottom. Each wagon drill is operated by a two-man crew. Holes are drilled to a maximum depth of 24 feet, with 4 changes of 1-1/4-inch round steel and carbide insert bits. These truck-compressor units are serviced in the pit each shift and moved by a truck driver only as needed.

Where the bench is at least 25 feet wide and a large number of closely spaced toe holes are needed, a self-propelled, self-contained drilling unit is used (fig. 3). With short moves this machine is capable of efficiently drilling large footages. The unit is mounted on four rubber-tired, widely spaced wheels. One large diesel engine provides power for traction, for operating the 315-c.f.m., piston-type compressor, and for the hydraulic system that operates the boom and drill feed. Traction of the unit under its own power is through a 2-speed transmission and chain drive at a maximum speed of 4 miles per hour. Although the unit can also be moved by towing with a bulldozer, it is not considered mobile enough to warrant moving an appreciable distance to a new location for drilling rounds of less than 15 holes. Drilling is done with a 4-inch drill with a 19-foot shell capable of operating with 16-foot changes of drill steel. Holes are normally drilled to a depth of 24 feet with 2 changes of 1-1/4-inch round steel equipped with insert bits. A pressure tank mounted on the unit carries a supply of water for one shift of drilling. This unit is operated by a driller with one helper. The machine is serviced each shift at the drilling site.

Blasting

Gelatin dynamite of 1-1/4- by 12-inch stick size and 60-percent strength is normally used in blasting by the Air-Drilling Department. A small quantity of explosives in 4- by 8-inch cartridge size is stocked for occasional mudcapping. When it is necessary to spring holes, an electric blasting cap in each hole is used to detonate the springing charge. Electric blasting caps are normally used to detonate the explosives in breaking boulders. In blasting down-hole and toe-hole rounds and occasionally in blasting boulders, Primacord is used to detonate the charge in each hole, and electric blasting caps are used to initiate the Primacord. Blasting machines of either 10- or 50-cap capacity are used, depending on the number of detonators to be fired.

In loading holes for a large blast the entire crew of the Air-Drilling Department may be used, working under close supervision. A five-man crew usually prepares the charge when blasting boulders. One of the powdermen carries a few sticks of explosives for preparing the charge. The other powderman, who carries the electric detonators, hands a detonator to the man with the explosives, who estimates the required charge, prepares the primer, and inserts the charge in the hole. The 2 powdermen are followed by the powdermen helpers, 1 of whom pours stemming into the charged holes, and the other 2 connect the lead wires.

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Figure 2. - Large mobile compressor unit.

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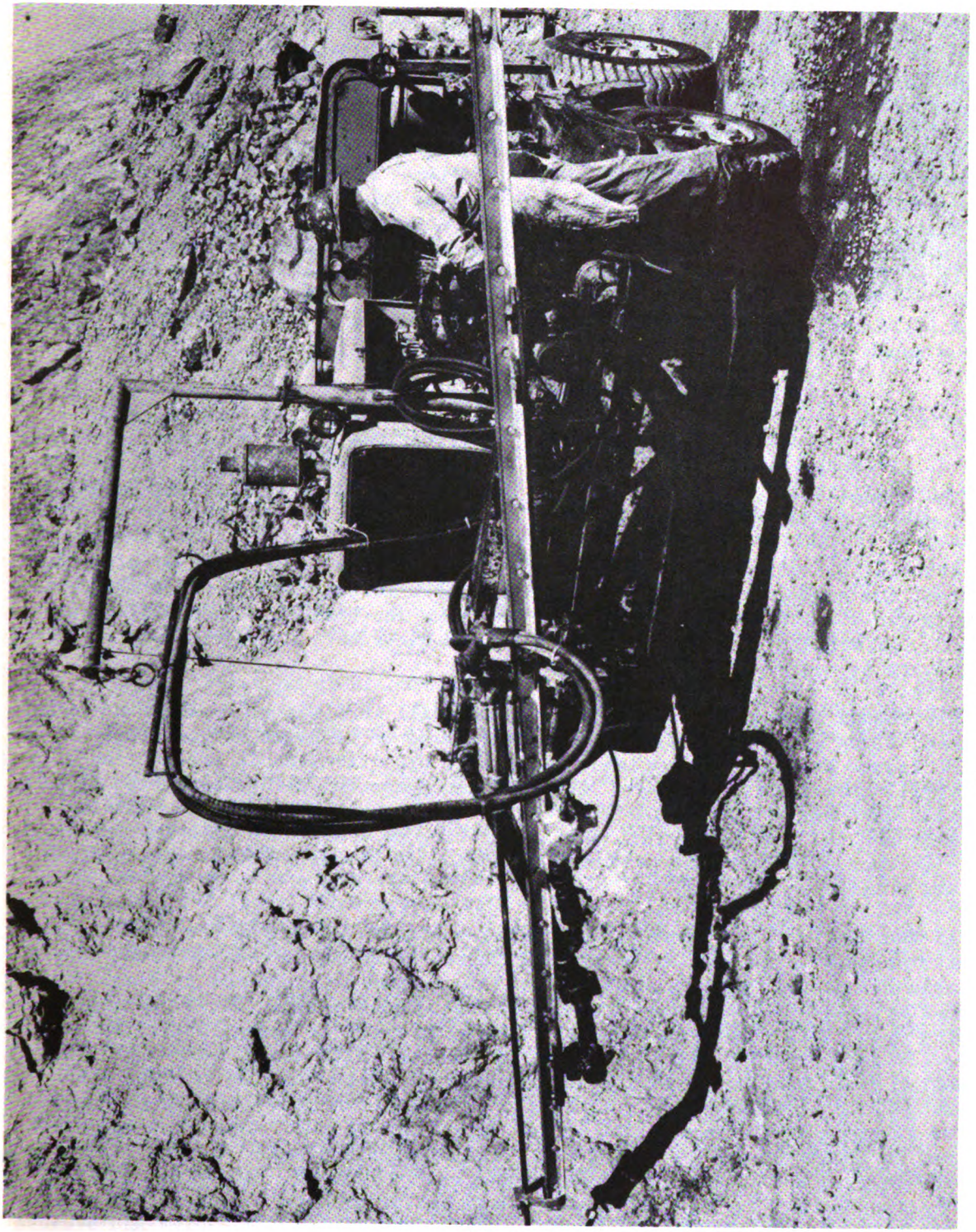

Figure 3. - Mobile drilling unit.

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Miscellaneous

Banks are effectively scaled to a height of 35 feet, using the loading shovels. The remainder of the bank is not normally scaled unless men or equipment is to work or pass in close proximity to a bank. Banks are scaled for toe-hole drilling and blasting, but are not usually scaled for drilling boulders and blasting. The boulders are placed by the shovel so as to be out of the zone of danger from sloughing of the bank. Banks are scaled by the Air-Drilling Department. Whenever water is available it is used both as a direct means of scaling and also to allay dust. Large boulders that cannot be taken down from banks by barring are blasted down, usually by plastering or mudcapping.

A 1-1/2-ton, stake-body truck is used to transport the crew, service equipment, and tow wagon drills.

SAFETY AND EFFICIENCY

Present Versus Past Drilling Practices

The changes in air-drilling practice have increased efficiency and therefore also resulted in safer operations.

By using portable compressor units, with subsequent elimination of air lines in the mine, the appreciable amount of labor required for installation and maintenance of these lines was eliminated, and therefore, the man-hours exposure was materially reduced. As working near the crest of banks is hazardous, a reduction in this type of activity is desirable.

The change from larger and heavier wagon-drill machines to smaller and lighter machines, along with a reduction in the maximum depth of holes and substitution of carbide insert bits for conventional detachable bits resulted in a reduction of each wagon-drill crew from 3 to 2 men. Improved air pressure with elimination of long air lines has resulted in better drilling conditions. The changes in drilling equipment and the ease of setting up for drilling at a new site have increased efficiency to such an extent that a marked reduction in the size of the air-drilling crew was possible.

As the small, truck-mounted, compressor units are driven by the drilling crew to the mine yard at the end of each shift where the units are serviced and supplies are replenished, transportation of the drilling crews and supplies is simplified. Inasmuch as the large, truck-mounted, compressor units and the large, self-propelled, drilling unit carry their own supplies, moving from one drilling site to another is relatively easy. The mobility of the truck-mounted units is of prime importance in increasing efficiency and reducing the man-hours of labor in moving. The change to carbide detachable insert bits resulted in a reduction in the quantity of supplies handled by reducing the number of changes of steel required. Thus, the man-hours of labor in servicing and supplying the drilling machines and in transporting men and equipment to the working areas has been greatly reduced. Actually, with former practice the cost of supplies and transportation for men and equipment was greater than the cost of drilling. Also, because of the mobility of the units and because each unit is self contained, only a general lineup is required of the foreman.

With former practice members of the air-drilling crew tended to travel up and down banks to connect hose to air and water lines. This hazardous practice has been eliminated. Vibration of air lines on the banks also tended to cause sloughing of the banks, which increased the hazards in drilling the toe.

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Because it is easier to keep up with the required secondary drilling with present practice, as a rule there are now smaller accumulations of boulders and the boulders are drilled and blasted with less difficulty. Also, because of the ease in getting equipment, compressed air, and water to the drilling site, boulders are drilled for blasting, and mudcapping and plastering have been virtually eliminated. This has reduced consumption of explosives, as a relatively small charge placed in a drill hole will do the same work as a larger charge placed on the surface of the boulder.

Because of the ease of drilling with the self-propelled drilling machine where short moves are involved, more holes are drilled at closer intervals to eliminate the need of springing holes. Thus the hazards involved in springing holes have been eliminated where this practice is followed.

Blasting

The principal supply of explosives and detonators is stored in well-constructed, permanent-type magazines in separate, isolated locations on the 5,200 level of the pit. Two magazines (fig. 4) store explosives and Primacord, and one magazine (fig. 5) stores detonators. An attendant on the day shift receives and disburses the supplies of explosives and detonators, and magazines are kept locked, except when adding to or removing from the stock. No one entering the magazines is allowed to carry matches, and containers in which matches and smoking materials may be deposited are provided at a safe distance. Cases of explosives and detonators are handled with utmost care, and an all-aluminum conveyor is used to facilitate handling. The magazine area is well marked with suitable warning signs.

Separate, box-type distribution magazines on the 4,850 level of the pit are used to store small quantities of explosives and detonators. These magazines are conspicuously painted, and suitable warning signs are posted in the adjacent area.

Explosives and Primacord used by the Air-Drilling Department are transported in a 1/2-ton pickup truck (fig. 6), which is used for that sole purpose. The truck is provided with a large wood box built of tongue-and-groove lumber with 2 separate compartments, 1 for Primacord and 1 for explosives. These compartments are kept locked, except when supplies are added or removed. The truck is prominently marked by signs and red flags and equipped with suitable lights, reflectors, and two fire extinguishers. Racks for transporting tamping sticks are also provided on the truck. Drivers of the explosives truck are required to proceed at low speeds.

Detonators are transported by the air-drilling crew in a locked, metal-covered, wood box attached to the bed of a 1-1/2-ton stake-body truck. The blasting machines are carried in a separate locked box. This truck is driven by one of the powdermen and is also used to transport the crew, the blasting-line reel, stemming, scaling equipment, and drinking water with a supply of dispensable paper cups.

In preparing the charge (fig. 7) for blasting boulders, explosives and detonators are carried in separate, small, wood containers provided with handles.

One of the powdermen of the Air-Drilling Department on each shift is assigned as powder distributor. He drives the explosives truck and carries the keys to the locks in the distribution magazines and to the blasting supply and equipment compartments on the trucks. Explosives are picked up at the distribution magazine at the beginning of each shift and checked back at the end of each shift. A complete record is kept of blasting supplies used on the various benches on each shift.

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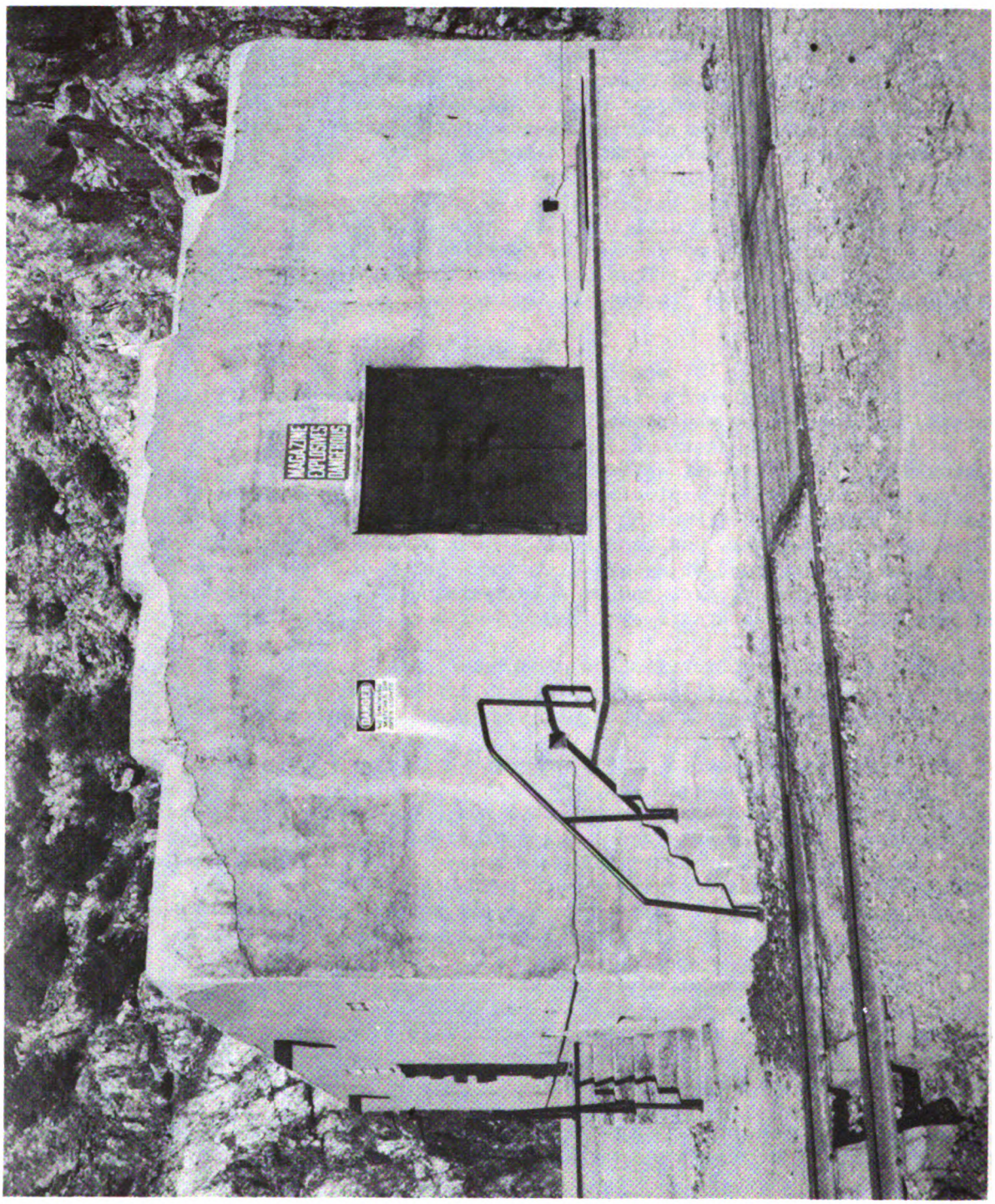

Figure 4. • Main explosives storage magazine.

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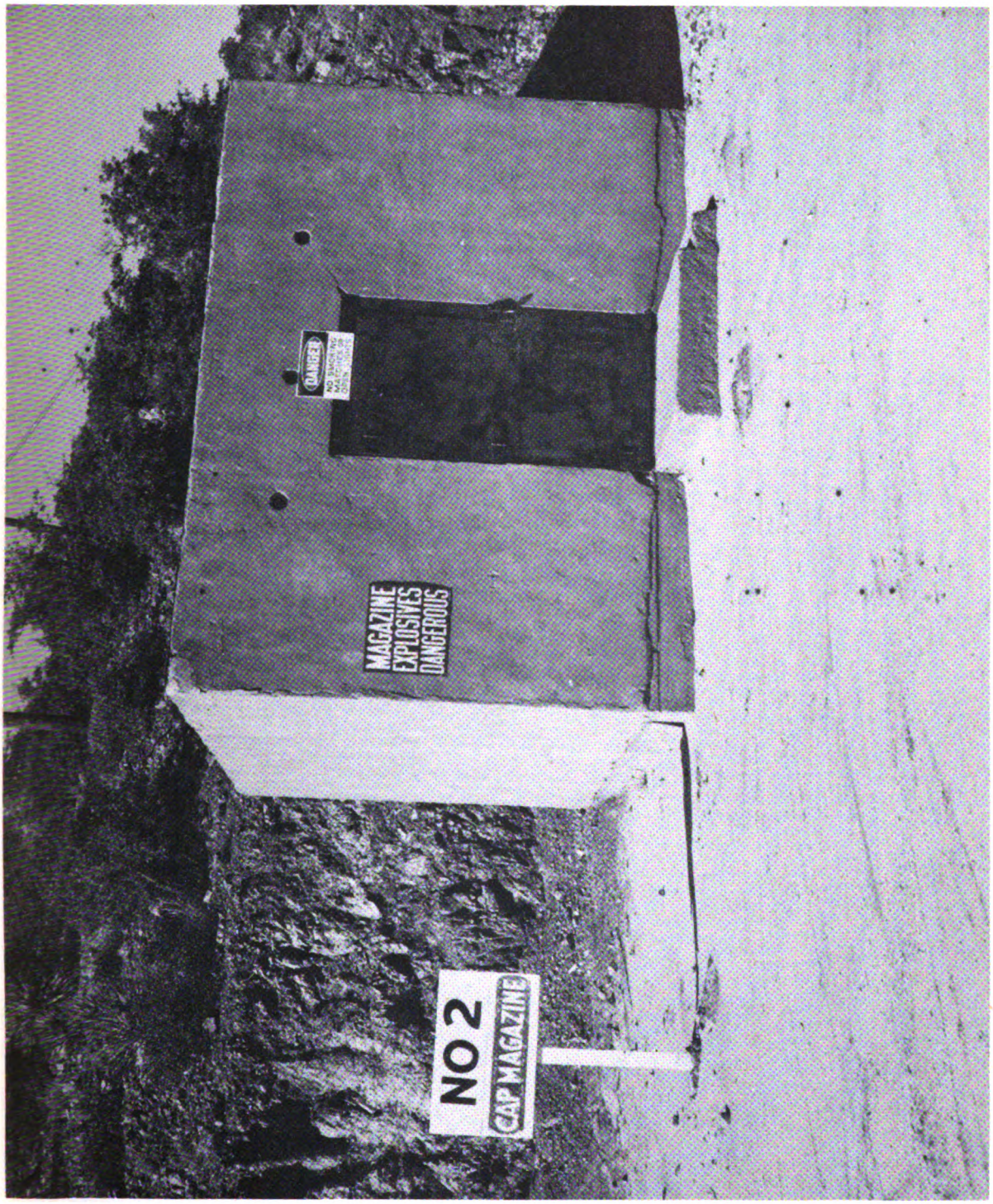

Figure 5. - Detonator magazine.

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Figure 6. - Secondary explosives haulage truck.

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Figure 7. - Preparing charge to blast boulders.

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Safety fuse is not used in blasting; the charge is detonated with electric blasting caps used either directly as the priming agent in blasting boulders or to initiate detonating fuse in all air-drill holes except those in boulders. In some boulder blasting, where it might not be possible to detect a misfire after the blast, detonating fuse is used as the priming agent. As an added precaution against misfires with toe-hole rounds 2 primers prepared with detonating fuse are placed in each hole, 1 at the end of the hole, and the other at the opposite end of the charge. With the 2 primers in 1 hole, the knots tying the detonating fuse from each primer to the trunkline are placed at least 4 inches apart to preclude any chance of the concussion from a high concentration of explosives at the knots causing a break in the blasting circuit. The Primacord blasting line is placed to make a complete circuit, so that each row of holes has two ways by which the detonating wave can reach it. Special precautions are taken to tie tight double-half-hitch knots in connecting the detonating fuse in the various parts of the blasting circuit and to lay out the blasting circuits so that the lines lie at right angles to each other and do not cross each other except at the connecting knots. A splice in detonating fuse is made with a square knot. Care is taken to insure that the loose end of the knot tying the detonating fuse from the primer to the trunk line does not cross the lines.

In electrical blasting with a 50-cap machine a maximum of 150 caps is fired at 1 time, and the round is wired in parallel series with a maximum of 50 caps in any single series.

Before blasting circuits are checked visually by the supervisors and electrical blasting circuits by galvanometers, guards are posted to see that the danger area is clear, and a warning whistle is sounded from the closest loading shovel. The blasting machine is warmed by operating it several times before connecting it to the circuit, and the machine is not connected to the circuit until it has been verified that the blasting area is clear. After the supervisor has checked by signal with the posted guards to verify that all is clear, either he or one of the powdermen fires the round. On signal from the supervisor an all-clear whistle is sounded by the shovel after the blast. Red flags are used in signaling.

If a round is only partly loaded and it is necessary for the crew to leave, the entrances to the area are marked by ropes and flags. With electrical blasting circuits, if an electrical storm is noted to be approaching, loading is stopped, and the portion of the round that has been loaded is fired if there is enough time. Otherwise, the crew clears and guards the area until the storm has passed. With detonating fuse, in case of a storm operations are stopped, and the area is properly guarded. If there is adequate warning of an impending storm, explosives and detonators are returned to the distribution magazines. Otherwise, the trucks are parked in separate isolated locations, and the areas are guarded with the crew in the clear.

After blasting the crew picks up all blasting-cap legwires and disposes of them. Any paper covering from explosives is also properly disposed of. These precautions are taken so that, if the loading-shovel operator notes either of these items in the muckpile, he will notify the blasting crew to search for a misfire.

The trucks used in transporting explosives and detonators are not equipped with radio equipment such as that used in some of the other vehicles in the mine for two-way communication. Transmitter equipment is kept at least 50 feet from electrical blasting circuits because of the possible danger of causing premature detonation by induced currents.

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As previously mentioned, very little mudcapping or plastering of boulders is done at this mine.

Tamping sticks used in loading holes are of wood, 1-1/4 inches in diameter and are originally of 16-foot length. Longer tamping sticks are obtained by joining two sticks with an aluminum coupling. A short length of rubber air hose is forced over the tamping end of these sticks to limit wear and to increase the area at the tip to give full purchase on the explosives cartridges. Stemming, consisting of fine gravel wrapped in paper to form a cartridge, is used in each hole.

Miscellaneous

Banks are scaled if there is deemed to be any possible danger. In scaling, men wear safety belts, and there is usually one man on top of the bank for each man scaling to feed out the rope as needed. Large steel pegs securely driven into the ground anchor the ropes. Whenever possible, water is used to allay dust produced in scaling.

The company endeavors to provide safe working conditions for all by providing and wholeheartedly supporting a complete safety program. This program provides for various safety committees, a safety department, safety training, protective measures, statistical analysis, and enforcement. As a part of this program the employees of the Air-Drilling Department participate by meeting periodically to study cause of and means of preventing accidents, to determine hazards and means of their elimination, and to determine safe operating practices. All members of the Air Drilling Department have been given preliminary instructions by the safety supervisor and the immediate foreman and take supplementary training at safety meetings. Machine drillmen's helpers are assigned to work with an experienced machine drillman. Men assigned to blasting are given detailed instructions by the foreman and assigned to work with experienced powdermen. Codes of safe practice, rule books, safety pamphlets, moving pictures, and slides serve in the education program.5/ All operations performed by the Air-Drilling Department are adequately supervised. New employees are given complete physical examinations; they must be physically fit for the duties they are to perform. All members of the working crew wear hard hats and safety-toed shoes. Safety goggles and respirators are worn when needed.

CODES OF SAFE PRACTICE

Codes of safe practice, used in training employees, comprise complete sets of instructions for each job and provide useful information, particularly for the safety education of newly hired or transferred employees. These codes also provide experienced workmen and supervisors with a clearer understanding of the details of the work and thus aid in obtaining efficient and safer operations. The codes for each job were prepared by men thoroughly familiar with the work and were carefully reviewed by a qualified committee, usually comprised of the head of the shop or department involved, a member of the engineering staff, a representative of the safety department, and 1 or 2 experienced employees. Codes are revised as needed with changes in practice.

Each employee, including supervisory personnel, is given a copy of the codes pertaining to the job and asked to read and study them. Parts of the codes, such

5/ Williams, M. L., and Look, A. D., Use of Visual Aids in the Morenci Branch Safety Program, Phelps Dodge Corp., Morenci, Ariz.: Bureau of Mines Inf. Circ. 7598, 1951, 6 pp.

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as the portions dealing with hazards or with points that might not be thoroughly understood, are discussed with each employee. After a few weeks the employee is examined on the safety codes applicable to his position. If the results of the examination indicate the need, the foreman discusses the codes with the workmen, spending the time necessary to give the employee a clear understanding as to the proper way to perform his work safely and efficiently. Safety codes are reviewed periodically in group discussions at committee meetings. True-or-false or multiple-choice questionnaires may be used in reviewing to check on the employees' knowledge of the codes.

Two codes of safe practice, Air Drilling, Open Pit Division and Primary & Secondary Blasting, Open-Pit Division, serve for the Air-Drilling Department.

Air Drilling

The following instructions are some of those set forth in the codes used by the Air-Drilling Department that are applicable to air drilling:

Machine drillman is responsible for seeing that banks are safe before drilling under them.

Machine drillman is responsible for the safety of the helper and for seeing that the helper performs his duties properly.

Before drilling in any location, inspect carefully for misfires from previous operations by examining boulders and toes and by blowing loose material from high bottom.

Inspect all banks to be sure that they have been properly scaled.

Never strike a bit with an ordinary hammer or with a rock. Use a soft hammer or a pipe wrench to install or remove carbide bits.

Lubricate threaded joints each time a bit is changed.

Wear goggles when collaring holes, blowing holes, or at any time when there is danger of dust or foreign particles entering the eyes.

Never strike a piece of drill steel unless drilling partner is in the clear.

Never drill dry except by direct order from the foreman, and always wear a respirator when drilling without water or when working near such an operation.

Drilling closer than 15 feet to a loaded hole is prohibited.

When drilling near a bank, face it.

Keep clothing and gloves clear of rotating steel.

Steel longer than 20 feet should be handled by 2 men.

Inspect the air hose connection to the machine frequently; connections with damaged threads should be discarded or repaired.

Use tongs when handling trailer cable.

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Use the proper method of lifting; face the object to be lifted, secure a firm grip, bend the knees, and take most of the weight on the large leg muscles instead of on the weak muscles of the back.

When placing an object, be sure feet and hands are in the clear before relaxing the grip.

Close the main air valve and release the pressure through the machine before breaking the hose connection.

Keep away from banks while primary blasting is in progress.

All persons scaling banks must be secured by safety belts tied with ropes to securely placed anchor bars.

Three-quarter-inch rope must be used for scaling. Inspect rope immediately before using it.

Discard or repair all damaged ropes or safety belts.

See that all persons and equipment are clear of falling rocks.

Keep unnecessary slack out of anchor ropes.

Keep ropes anchored directly in back of the man using the scaling bar.

Never attempt to loosen material from below; stay above it or to one side.

Do not advance to a lower position until it is certain that no material is left behind to fall.

Use judgment when barring large masses of loose material; when one part is loosened all of it may slide.

At least one man must remain at top of bank to attend to anchor bars and ropes.

Be sure the pressure safety valve on the air receiver tank is working properly.

Examine all boulders for misfires before they are drilled.

High bottom to be drilled must first be cleaned off with a blowpipe and compressed air.

Do not jump from boulder to boulder.

Drill boulders from the side when the footing on top is insecure.

Watch footing, and do not hurry when carrying equipment over broken ground.

Guard against injury when a drill steel breaks. Keep braced and balanced with the feet wide apart.

When a wagon drill is working under a high bank, a third crew member may be assigned, at the discretion of the foreman, to watch for signs of bank movement.

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Obstructions must be moved from the vicinity of the drill.

Drillers must stand outside the frame of the drill.

Crew members must not stand on the wheel for any purpose.

Using the valve chest to push steel into position is forbidden.

Holes must be kept clear. When a drill is stuck it must be removed, and the hole should be blown out before further drilling is done.

While the drill is in use or being moved, the clamps on the tubular columns must be secure.

When not in use the machine should be left at the balancing point.

Examine drill steel for worn threads and battered shank ends and to see that the water passage is clear.

See that hoses are free from breaks, connections are snug, and crossover devices are in place across roadways.

Blow out hoses and air lines, making sure that every one is in the clear.

See that all tools are in good condition.

Keep the working place clear of stumbling hazards.

Never use gasoline or lubricants to build or to feed a fire.

Do not build open fires. All warming fires are prohibited except in the approved type of stove.

Gasoline may be transported only in the approved type of airtight container.

When filling a gasoline tank from a fuel container, set the can on the ground before beginning to pour.

Avoid spilling lubricants or fuel on the clothing.

Wear gloves and use bars when moving hot stoves from one location to another.

Never approach a fire of any kind with fuel or lubricants on the clothing.

Gasoline engines must be stopped while the gas tank is being filled.

In case of emergency, notify the foreman. If the foreman is not immediately available, call the dispatcher.

When a misfire is found, all drilling in the immediate vicinity must be suspended and the area must be guarded until the foreman can be notified.

All accidents resulting in personal injury, regardless of seriousness, must be reported at once to the foreman in charge of the work. The foreman must see that injured employee receives medical treatment and must make out a written report on the accident as soon as possible.

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Blasting

Following are some of the instructions set forth in the codes used by the Air-Drilling Department that are applicable to blasting operations performed by that department:

Gloves should be worn when handling rough material.

All persons who work in the pit at night must provide themselves with a hand light.

Crew members must report immediately to the foreman any dangerous condition or practices that may come to their notice.

Employees must never direct a stream of water or compressed air in the direction of anyone.

Watch footing when getting on or off trucks or when walking about the pit, especially when carrying a load.

A qualified foreman must personally supervise the loading and firing of all blasts.

No persons working with the powder crews are permitted to carry any but safety matches.

No one is permitted to handle explosives except those who have been thoroughly instructed and trained in the standard practice.

Rough handling of explosives or detonators is prohibited. One box of explosives may not be slid over another, and boxes must be placed in position carefully; they must never be dropped or allowed to fall.

Smoking in the vicinity of explosives or while handling explosives is not permitted, and fires must be kept at a safe distance.

Explosives must never be left unguarded at any time.

Power cables must not lie in zones being loaded for a blast.

All explosive charges must be covered with stemming as soon as they are loaded.

Blasting caps may not be used in any drilled holes, except for springing and for blasting boulders.

When a blast is to be left loaded overnight the protruding ends of Primacord must be kept dry.

Explosives must never be handled in a thunderstorm. When the first threat of a storm is observed boulders that are loaded and primed with electric blasting caps should be shot, if possible. If they cannot be shot, the cap wires in the loaded holes should be short circuited, unused explosives and detonators should be returned to the field magazines, and the area around the loaded zone guarded as for a blast.

The firing of a blast should always be immediately preceded by a careful look to see that everything is safe.

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Trucks used to haul explosives must be in first-class mechanical condition; they must be equipped with a wood floor having all nails or bolts countersunk.

Engine, pan, chassis, body, and all compartments of powder trucks must be cleaned at regular intervals and be kept free from accumulations of surplus oil and grease.

Smoking on or near a truck carrying explosives is prohibited.

When it is necessary to take a powder truck to the shop for repairs, all explosives must first be unloaded. A guard must be placed in charge of the explosives unless the powder crew is present or unless the explosives are locked in a field magazine.

Powder truck drivers or a powder distributor must report immediately to their foreman any repairs needed by the powder trucks.

Blasting caps must never be carried in the same vehicle with other explosives.

No other material may be hauled in the same vehicle compartment with powder.

Foreman in charge of blasting operations will check at least once each shift to see that regulations concerning the distribution of explosives are complied with and to see that the powder trucks are properly maintained.

When roads are slippery, powder trucks must be equipped with chains.

A field magazine keeper (powder distributor) will be in charge of the distribution of explosives and blasting caps for secondary work.

The powder distributor will keep complete and accurate records of receipts and issue of explosives.

The powder distributor is responsible for the care and operation of the field magazine truck.

The driver and one passenger only may ride in the field magazine truck.

A maximum of 10 cases of explosives may be kept in the field magazine truck.

After blasting supplies have been delivered the field magazine truck will be moved from the vicinity of the loading zone. A minimum distance of 50 feet must be maintained between the truck and the loading zone.

During an electric storm the field magazine truck will be parked away from all operations; the powder distributor will stay on guard a minimum distance of 500 feet from the truck.

Air-drill holes must be sprung one at a time.

After a hole has been sprung other explosives may not be introduced until it is determined that the hole has cooled enough for safe loading. A wood tamping stick or a wood dolly that is cool to the touch after being left in the hole for a few minutes is considered an indication that the hole is cool.

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No holes may be sprung closer than 100 feet to a loaded hole.

No one may remain close to a loaded hole while nearby holes are being sprung.

The foreman must closely check the amount of powder used in loading air-drill holes.

All air-drill holes except those in boulders will be detonated with Primacord.

One primer placed at the bottom of the charge is considered sufficient for high bottom or other vertical air-drill holes. Two primers, one at the bottom and the other near the top of the charge, must be used in toe holes.

Powder charges in air-drill holes, other than those in boulders, should be compacted by a gentle but firm push with the standard wood tamping pole at suitable intervals during loading. Striking the charge violently with the tamping pole is dangerous.

Only a standard wood tamping pole may be used when compacting the charge in air-drill holes. When loading vertical holes the pole must be long enough to extend past the head of the person using it when the pole is resting on the bottom of the hole. When loading toe holes, powdermen must stand to one side and not place their hands over the end of the pole.

When toe holes are being loaded in broken ground, a nonsparking tube should be used to load through if it appears that powder may be lost in cracks or fissures.

Insofar as possible, toe holes will be blasted in advance of churn-drill holes.

No boulders will be loaded that would be covered after the blast, making detection of misfires impossible.

Attach branch lines to the main line of Primacord with a double half hitch and the ends of Primacord together with a square knot.

Loose ends resulting from tying branch lines to the main line of Primacord will be cut off and delivered to the field magazine keeper.

When toe holes or multiple rows of holes are to be blasted in conjunction with a main line of holes, both ends of each branch line must be tied to the main line of Primacord to form a complete loop.

When branch lines are attached to a main line, the lines of Primacord will lie at right angles to each other.

Electric caps of different brands should not be used in the same blast.

In accordance with the recommendations of explosive manufacturers, the number of caps in any series should not exceed 50. Several such series may be blasted when using a power circuit as the source of current provided calculations are made to insure that there is a current of 1.5 amperes available for each series in the circuit and 1.5 volts for each cap in each series.

Test to find an open circuit. Connect ends of various parts of the circuit to the terminals of the circuit tester until one is found that will not cause the needle to deflect.

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Use only the silver chloride cell made for the purpose to furnish current for a circuit tester. Flashlight batteries must not be used since they deliver enough current to explode a cap.

Short-circuit the terminals of the circuit tester before using it. If the needle travels all the way across the scale, the condition of the silver chloride cell is satisfactory.

Before using the circuit tester to determine approximate resistance, it must be calibrated by connecting circuits of known resistance across its terminals and comparing readings obtained on the scale with the known resistances.

Guard against introducing stray currents into an electrical blasting circuit. Keep all wiring from coming in contact with rails, pipelines, machinery, churn-drill or shovel-trailing cables, or any other possible conductor of electricity. Keeping end of cap wires or the parts of the circuit wired together until the time for tying them into the main circuit forms an effective ground for stray currents.

The foreman will personally instruct each guard as to the territory for which the guard will be responsible.

All guards must be provided with red flags.

All guards must understand the system of signals used for blasting.

Wind velocity and direction must be considered when placing guards for springing.

When placing guards for toe-hole blasts, bear in mind the possibility of a blowout.

When the whistle signal is sounded, guards will immediately clear all persons from the territory they are to guard and prevent anyone from entering the territory until after the clear signal is given. The man who is to fire the blast will make final preparations as follows:

1. Attach cap to Primacord.
2. Place blasting machine in a position from which the blast may be safely fired.
3. Keep ends of leading wire grounded (wired together) until signal to blast is given.

When the foreman has received clearance signals from all the guards and is sure that no property or persons are in danger, he will give the signal to fire.

After blasting, the foreman will inspect the shot for indications of misfires. If a misfire is found, the location will be suitably marked with red flags, and a report made to the drilling and blasting foreman.

After an electric cap blast all exposed wires must be tested with a circuit tester and removed from the blast.

Immediately after the blast, empty boxes and papers will be burned.

Powder from misfires shall be taken to the Secondary Powder Magazine and disposed of according to the foreman's instructions.

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Powder truck will be inspected at the beginning of each shift as follows:

1. Tie rod, drag link, and steering arm.
2. Inspect tires for wear, inflation, and lug bolts.
3. Springs.
4. Oil, water, and fuel.
5. Brake test when starting.
6. See that oil pressure gauge is working.
7. See that truck is free of excess oil or grease.
8. See that truck is equipped with wood floor and that there are no protruding nails or bolts.
9. Be sure truck is clean and in first-class mechanical condition in all respects. Discard or have repaired any tool found to be in bad condition.

Before explosive is delivered to the location of a blast, all power cables, churn-drill bits, casing, scrap metal, wood, or other materials except equipment to be used in loading, must be removed from the area.

Empty boxes and waxed paper are to be neatly stacked in piles outside the loading zone where they can be burned after the blast.

Lunch scraps, paper, and other refuse will be picked up and burned after the blast.

The foreman should be notified each time the fire extinguishers (carried on the powder truck) are used.

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